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The problem of decay in the management of poplars in Alberta

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THE PROBLEM OF DECAY IN THE MANAGEMENT

OF POPLARS IN ALBERTA

by

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INTRODUCTION

Aspen, *Populus tremuloides* Michx. and balsam poplar, *Populus balsamifera* L. are widely distributed throughout Alberta. Aspen occurs extensively in pure stands in the main parkland of central Alberta, and is regarded by Moss (1932) as the climax species of that region. In the Boreal Forest Region to the north of this parkland aspen is a pioneer species, eventually being replaced by more tolerant conifers.

Balsam poplar is a pioneer species on the bottom-lands surrounding rivers in the Boreal Forest. It is found in mixture with aspen on the moister upland sites.

The volume of poplar saw-timber (10-inch d.b.h. and over) in Alberta was estimated in 1956 to be 61,144,000,000 board feet, or about 48 per cent of the total volume of saw-timber. In addition to this there were 135,077,000 cords of smaller material (under 10-inch d.b.h.), making up about 38 per cent of the total volume of this type of material in the province (Anonymous 1957). During that year there were approximately 4,000,000 board feet of poplar cut, amounting to less than one per cent of the total cut for the province.

Three plywood mills manufacturing poplar faced veneer have been established in Alberta since 1953.

Balsam poplar is the preferred species for peeler logs as high quality trees are found in abundance on the bottomlands. Aspen stands containing enough logs of peeler quality to justify logging are rare, and the utilization of this species is rapidly ending. As the supply of available balsam poplar decreases, the plywood companies may change to equipment that can economically handle smaller logs. Aspen would then again be in demand.

The availability and ease of management of poplars may some day attract a pulp market to these species in the west. Schafer (1947) reports that the yield of chemical pulp that can be obtained per cord of wood is nearly comparable to that of some of the conifers. The relatively low weight of aspen is compensated by the relatively high cellulose content of this wood. Other qualities of aspen such as softness, uniform texture, white color, light weight, ease of gluing, and low shrinkage make it ideally suited to uses where strength is not required. Balsam poplar has almost identical properties to aspen, except in color. The darker colored heartwood, with the resulting contrast between heart- and sapwood add to the beauty of the finished veneer.

Decay is probably the most serious factor limiting the increased utilization of these species. Foresters and lumbermen have generally assumed that aspen and balsam poplar were highly defective species. This assumption has led many of them to believe that the only good use for poplars is as a nurse crop for the spruce that may be present in the understory. Aside from attempting to lessen the prejudice against aspen and balsam poplar the purposes of this study are: to derive decay per cents that can be used in the provincial forest inventory and forest management plans, and; to identify the fungi responsible for the decay in poplar.

CHAPTER I

REVIEW OF THE LITERATURE RELATING TO DECAY LOSSES IN POPLAR

Decay studies have been undertaken throughout the major part of the commercial range of aspen. Balsam poplar, although growing in close association with aspen over most of their range, has been neglected by these studies. This literature review touches only lightly on the facts brought out in the cull studies as they are reviewed in greater detail under the appropriate headings within the body of the thesis to follow.

Schmitz and Jackson (1927) in an early study of aspen in Minnesota found the percentage of decay to increase from 14.8 at 30 years to 31.2 at 70 years of age. Branch stubs were considered the most important entrance points for the fungi, with fire scars and insect injuries of secondary importance. A pathological rotation of from 40 to 50 years was recommended with the elimination of fires from the stands an important consideration in the management of aspen.

Meinecke (1929) working in Utah on site I and II aspen lands found decay to increase from 1.46 per cent at 30 years, to 44.75 per cent at 130 years of age. Fire scars are listed as the most important entrance points for the decay-causing fungi. A considerable amount of decay was found to have entered through a canker of unknown origin which was prevalent in the area. The author recommends a pathological rotation age of from 80 to 90 years. He believes that the amount of decay can be materially reduced as the stands are brought under management with the elimination of fires and defective trees from the stands.

Zehngraff (1947) presents figures showing the relation between cull per cents and vigor class based on dominance, crown density, and relation to surrounding trees. The average cull of the highest vigor trees amounted to 5 per cent and increased to 50 per cent in the lowest vigor trees. He concludes that diameter cuttings which remove the larger trees will leave the more defective trees as growing stock.

Riley (1952) working in aspen stands at Petawawa, Ontario found the percentage of decay to increase from nil at 30 years to 4.07 at 70 years of age. No relation between decay and site could be established on the basis of cubic foot volumes, but a slightly higher percentage of cull occurred on the poorer sites when trees were scaled in board feet. The low amount of decay found in this study is due in part to measuring only advanced decay, and rejecting that which had entered through scars.

Black and Bourchier (1952) in the Manitoulin area of Ontario found the percentage of decay in aspen to increase from 1.5 at 50 years to 25.9 at 110 years of age. A slightly higher percentage of decay was found in slow-growing trees than in fast-growing trees.

Kirby et.al. (1957) in a growth and yield study of aspen in Saskatchewan found the percentage of decay to increase from 2.6 at 30 years to 46.5 at 100 years of age. A pathological rotation of from 70 to 80 years is recommended, although the authors realize that this will greatly curtail the potential gross volume of the stand, and produce material below the optimum size for lumber and plywood manufacturing.

Basham (1958) reporting on a study done in the Upper Pic Region of Ontario found that decay per cent increased from 1.0 at 60 years to 17.3 at 180 years of age. He states that approximately 90 per cent of the trunk rots could be traced to dead broken branch stubs. There was a distinct tendancy for aspen to have a greater volume of butt rot on dry sites than on any others.

CHAPTER II

LOCATION AND DESCRIPTION OF THE STUDY AREA

This study was undertaken during the summers of 1957 and 1958 in the west-central portion of Alberta. Forty-three, one-tenth acre square plots were established in poplar types in the three forest divisions located in this area. Table I and Plate I show the distribution and location of the sample plots.

TABLE I

DISTRIBUTION OF SAMPLE PLOTS

AREA	NO. OF PLOTS
Slave Lake Division	
1. Swan River	4
2. Faust	17
Whitecourt Division	
3. Whitecourt	6
Grande Prairie Division	
4. Simonette River	8
5. Goodwin	8
Total Plots	43

Topography

The area is classified by Halliday (1937) as B18, the mixed-wood section of the Boreal Forest Region. Aspen and balsam poplar are the dominant forest cover, occurring in pure stands and mixed with coniferous species.

Elevations in the study area varied from 2,000 to 3,000 feet above sea level. Lesser Slave Lake to the northeast of the area has an elevation of 1,980 feet, and Grande Prairie to the west is 3,300 feet above sea level.

Flat to gently sloping relief is characteristic of the area except where broken up by the valleys of rivers. A range of hills with elevations up to 4,500 feet extends into the south and east of the area. These hills support a cover of lodgepole pine *Pinus contorta* var. *latifolia* Engelm. and white spruce, *Picea glauca* (Moench) Voss which closely resembles the sub-alpine region on the eastern slope of the Rocky Mountains.

Climate

The climate in this portion of central Alberta is characterized by moderately warm summers and relatively cold winters with a mean annual temperature of about 35 degrees Fahrenheit, and a growing season of about 100 days. Although the annual precipitation amounts to only 18 inches, approximately 70 per cent of it occurs as rainfall during the growing season, and a very lush growth of vegetation is found over the area.

Soil

Soils of the area have developed mainly from the glacial till deposited during the advance of the Laurentide ice sheet from the northeast. This till is composed partly of materials brought in by the glaciers and partly of heavy textured materials accumulated from the underlying bedrock. Underlying formations are mainly of Upper Cretaceous Age, consisting largely of shales and sandstones. Soils adjacent to the rivers have undergone considerable alteration. Profiles on these bottomlands consist of layers of sand and silt, sorted and deposited by running water. Some soils in the Whitecourt area appear to have formed directly from the underlying sandstone. It is possible that these areas escaped glaciation.

Vegetation

Hardwood stands in the Boreal Forest Region of Alberta are composed essentially of three main types: pure aspen; mixed aspen and balsam poplar, and; pure balsam poplar. These are pioneer types invading burned areas, old fields, and coming in as natural succession on alluvial land. In the absence of destructive agencies these stands are converted to the mixed-wood type as white spruce becomes established in them. The pure hardwood type survives only in the presence of such destructive agencies as fire, cutting or flooding.

Each of the types are well defined as to the sites on which they occur and the vegetation composing them. The following are descriptions of the three hardwood types:

Pure aspen type: This type occurs on the driest of the poplar sites, on sand or heavy clay soils. Aspen is the main component of the stand with white spruce or lodgepole pine becoming a minor component as maturity is reached. In the absence of fires this type is readily converted to the mixed-wood type, and it is in these stands that the highest quality spruce is produced. Many stands never become merchantable due to the small size and poor form of the aspen. One of the most striking features of this type is the lack of a high shrub layer giving a parklike appearance to the stands. However, a number of low shrubs are present, among which are *Shepherdia canadensis* Nutt., *Ledum glandulosum* Nutt., *Rosa* spp., *Vaccinium* spp., and *Lathyrus* spp.. Common herbs are *Linnaea borealis* Gr., *Aralia nudicaulis* L., *Cornus canadensis* L., *Fragaria glauca* L., *Lycopodium* spp., and *Arctostaphylus* spp.. Grasses and mosses are also found in association with this ground cover.

Mixed aspen-balsam poplar type: This type occurs on the moister upland sites. Soils are mainly loamy, although sandy soils with a water table within reach of the tree roots will support the type. White spruce reproduction is not as commonly found as in the pure aspen stands. This may be due to the denser canopy in the mixed type. Volumes per acre are much greater in the mixed than in the pure aspen stands. Aspen attains its maximum development but balsam poplar produces larger and better formed trees (Plate 2). A dense shrub layer is ordinarily present. Common high shrubs are Alnus crispa Pursh., Cornus stolonifera Mx., Viburnum spp., and Salix spp.. Low shrubs and herbs commonly found are Lonicera involucrata Banks, Aralia nudicaulis L., Petasites palmatas Gr., Arnica cordifolia Hook, Smilacina stellata Hook, S. racemosa Hook, Streptopus amplexicaulis Poir., Galium boreale L., Cornus canadensis L., and Pyrola secunda L..

Bottomland balsam poplar type: Balsam poplar is the first tree species to invade the recently deposited soils along stream banks. On these sites it reaches its maximum development, attaining heights of 110 feet and diameters of to 50 inches, (Plates 3 and 4). These trees produce high quality veneer logs as they have little taper, and as much as half of their height may be free from branches. White spruce readily invades this type, and mature stands of pure balsam poplar are rare. High shrubs are present, although not as abundant as in the mixed type. Cornus stolonifera, Alnus crispa, Viburnum spp., and Salix spp. compose the shrub layer. Equisetum spp., Hypnum spp., and Hylocomium spp. are the only abundant ground cover plants.

CHAPTER III

FIELD AND COMPILATION METHODS

Field Methods

The data in this report comprise the measurements of 1136 trees on 43 sample plots, selected to include the types and age classes needed for the sample. Plots of one-tenth acre in size were located at random in the three poplar types previously described. A starting point was located and plots were laid out at even intervals from this point. Accessibility limited the distribution of sample plots within the study area.

A post with an aluminum tag was driven into the ground to mark the northwest corner of each plot. Plot boundaries, of 66 feet to the side, were laid out in cardinal directions with a compass and marked by means of a string line. Description of the plot included locality, topography, slope and aspect, herb and shrub associations, soil profile and, disturbances.

All trees 3.6 inches d.b.h. and over were felled and cut into bolts 8 feet 8 inches long, to a top diameter of 3.5 inches inside bark. This log length is that utilized by plywood companies in Alberta.
All other measurements were made to conform with the forest inventory specifications. Age at stump height was taken when possible. If it could not be determined

due to the presence of butt rot, the age was estimated by comarisons with trees of similar diameter on the same plot. Diameter inside bark and diameter of decay were measured at each cut and plotted over their appropriate height on a semi-logarithmic scale on the back of the individual tree card. If decay showed at one end of the bolt only, it was further sectioned to determine the extent of the decay within the bolt. Decays were measured in cubic feet according to the procedures set down by the Western International Forest Disease Work Conference and published by Foster (1958). Each tree was also scaled and culled in board feet following the scaling rules of the Government of Alberta (Undated). Decays were described in the field and assigned a tentative identification when possible. If the entrance point could be determined it was noted on the tree card and its position plotted on the graphic diagram. The trunk and dead branches were checked for the presence of sporophores. All visible defects were plotted on the diagram. Other data recorded on the individual tree card were species, age, d.b.h., total height, crown class,and condition.

A sample of each decay encountered was shipped to the Calgary Laboratory of Forest Pathology for culturing and identification. Cultures which could not be identified in this laboratory were sent to Dr. M.K. Nobles, Senior Mycologist of the Dept. of Botany and Plant Pathology, Ottawa, for identification.

Compilation Methods

Decay values represent the actual cubic foot volume of decay present from a one foot stump height to a 3.5 inch top diameter. Cull values represent the board foot volume of decay present from a one foot stump height to a 6 inch top diameter. A one inch trim allowance is added to each decay measurement in board foot scaling. If a log contained more than 66 per cent cull, it was culled 100 per cent.

Cubic foot volumes were computed by Smalian's formula (see Appendix). Board foot volumes were determined by the International 5/16-inch Log Rule. This rule, in official use by the Alberta Government, is a formula reduction of the International ¼-inch Log Rule.

CHAPTER IV

DECAY LOSSES IN ASPEN AND BALSAM POPLAR

Decay in Relation to Age

Nearly all species exhibit a relationship between the prevalence of decay and tree age, with this relationship usually more marked in the more defective species. A combination of factors may be responsible for this relationship, among which are the cumulative risk of infection with increasing tree age, a possible higher percentage of heartwood present in the older trees, or a reduction in the decay resistance of the heartwood of older trees (Wagener and Davidson 1954). The latter of these factors appears to exhibit the least effect in poplar as the heartwood of poplar does not seem to possess any great decay resistance at any age.

Incidence of decay: The relationship between tree age and the incidence of decay is shown in Table IV. All aspen over 60 years of age and all balsam poplar over 40 years of age contained decay causing organisms. The average percentages of 89.6 for aspen and 93.2 for balsam poplar may be slightly misleading, because although aspen has a slightly lower incidence of decay it has a much higher percentage loss in the decayed trees.

<u>Losses in merchantable volume</u>: Tables V and VI show gross and net volumes, increments, and decay per cents for aspen and balsam poplar. The percentage of decay in aspen rises from nil at 20 years to a maximum of 33.2 at 100 years of age. The percentage of decay in balsam poplar rises from nil at 20 years to 17.2 at 150 years of age. The indicated net volume recoveries in this study may appear excessively high to those who are familiar with logging poplar. It should be noted though that in cubic feet scaling all sound wood is classed as salvagable. Most of this sound wood was contained in partially defective logs. It would therefore be necessary to fall and buck all trees, and to utilize all sound material to obtain the net volumes indicated. This practice would produce excessively high costs of logging, bucking, yarding, hauling, and milling. Also it should be noted that no logs were culled through reason of decay, as is done in board feet scaling, the net volumes derived in some cases from logs containing as much as 90 per cent of decay.

Decay in Relation to Rate of Growth

Analysis of the data at the end of the first summer of field work indicated that there might be a lower percentage of decay in poplar on the good sites as compared with the poor sites. Accordingly a hypothesis was formed that site quality may exert an influence on the rate of decay in poplar. In order to test this hypothesis, sites were classified into as broad groups as possible and the field work during the second summer was aimed at getting a complete range of age classes on each site. The site classification used was based on the ecological aspects of the stands as outlined on pages 10, 11, and 12. Existing site index tables were believed to produce results lower than are encountered in poplar stands in the northern part of the province. This is especially true of the bottomland stands which may exceed the highest site index by as much as 20 feet in the older age classes.

Analysis of the data after two summers field work revealed that no appreciable difference existed between the percentage of decay on good and on poor sites. The data for each site were therefore grouped and form the basis for Tables V, and VI.

Another method used to test the effect of growth rates on decay per cents is to divide the trees into fast- and slow-growing classes and analize these data separately. The method, as outlined by McCallum (1928), is as follows; the gross volume for each tree is compared with the average gross volume for all trees of the same age. Trees above above average volume are considered fast-growing, and those below are considered slow-growing. Tables VII, and VIII present the results of this analysis.

The average decay per cent for fast-growing aspen is 26.0, and for slow-growing aspen the average is 34.9 per cent. The difference between the percentages of decay are fairly consistent throughout the sample. Fast-growing balsam poplar average 8.8 per cent decay whereas the slow-growing trees average 16.8 per cent. The greatest difference between decay per cents occurs in the younger age classes, and this difference disappears as the stands increase in age.

It would appear from this analysis that site does influence the amount of decay present in the stands. The method of site classification used in the study may not have been the correct one to show a difference in decay existing between sites. However, many slow-growing trees occurred on good sites, and many fast-growing trees occurred on poor sites. Part of the difference in amount of decay must then be due to differences within individual trees instead of to site quality alone. The poplar cull study is being continued in Alberta through the next field season to include extremes in site quality, and a difference may be accounted for in the final analysis of the data.

Decay Losses by Forest Inventory Specifications

The Alberta forest inventory has been done by aerial photograph interpretation with corresponding ground checking. Variables used in computing volumes are species composition, stand density, and stand heights.

Two types of inventory have now been completed: a general inventory using species, heights, and stand density, and; a detailed inventory using sites and maturity classes in addition to the variables in the general inventory. Aspen and balsam poplar have not been differentiated in the forest inventory figures.

Tables IX, X, and XI present cull figures in board and cubic feet for the general and detailed inventories. As height classes somewhat reflect age classes, a trend would be expected to increasing cull with increasing height. Inspection of the percentages for the general inventory reveals that no such trend exists in these figures. A number of reasons may be given for this lack of conformity. Height class 3 consists of many mature aspen in pure stands and younger aspen and balsam poplar in mixed stands. The older aspen in the pure stands may be responsible for the high cull per cent. Height class 4 consists of a larger proportion of balsam poplar, giving rise to the lower percentage of decay. Height class 5 consists of bottom-land balsam poplar stands with their lower amounts of decay in comparison with their gross volumes.

The detailed inventory exhibits a more pronounced trend towards increasing decay with increasing height. The variation between decay per cents on good and medium sites is believed to be due more to species composition than to a difference in decay on the various sites. Medium sites supported, almost entirely, pure aspen stands, whereas good sites supported mixed and pure stands of balsam poplar. The lower amount of decay in the balsam poplar makes up the greatest portion of the difference in decay between sites.

Poor sites, on the basis of the site index used in the forest inventory, were not encountered in the study.

It is believed that these exist only on such adverse sites as the sand dune areas near Grande Prairie, or on areas where growth may be inhibited by high water tables or prevailing winds.

CHAPTER V

INFECTION COURTS FOR THE DECAY CAUSING FUNGI

Infection by decay-producing fungi may take place when spores of the fungi come in contact with exposed wood, if temperature and moisture conditions are favorable. The moisture content of the exposed wood must be at or above the fiber saturation point in order that fungal spores may germinate. Precipitation in the study area during the spring and summer months amounts to approximately 14 inches, evenly distributed throughout the season. Relative humidity is maintained at a fairly high percentage by these frequent storms. Very favorable conditions are produced for infection of trees under these conditions, as exposed surfaces are not able to dry out for any appreciable period of time.

Branch stubs were found to be the most important infection court, with possibly 80 per cent of the infections attributed to them. Scars on the trunk and butt of the trees formed the other major type of infection court for the fungi.

Fire scars (Plate 5) resulted in more decay than scars of similar size produced by other agencies. Aspen is relatively thin barked, and light surface fires will expose the under-lying wood. Balsam poplar on the other hand is a thick barked tree, and although fires rarely expose any wood, they may result in the death of the cambium, and infection takes place as the bark cracks over the dead areas. Meinecke (1929) found fire scars to be the most important entrance points for fungi attacking aspen in Utah. Schmitz and Jackson (1927) in Minnesota found them to be of second importance, ranking after branch stubs. These authors believe that fire may influence the moisture content of the wood for some distance from the scar, and allow free entry of air, thus making conditions more favorable for rapid decay. The moisture content of poplar wood is probably high enough at times to inhibit the growth of fungi due to the exclusion of oxygen from the wood. This explanation might account for the greater amount of decay associated with fire than with other scars.

The amount of decay associated with fire scars has been the subject of a number of studies on various species. It has been correlated with age of the tree, percentage of the circumpherence scarred, diameter of the tree at the time of the fire, length, width, and area of the scar, and the fungus causing the decay (Hepting 1935, 1941, Kauffert 1933, and Nordin 1958). All fire scars found in this study were infected, and the amount of decay associated with them could probably be correlated more closely with the time since the fire than with any of the previously mentioned indications.

Mechanical injuries to standing trees produced by other trees brushing them result in shallow scars confined to the sapwood. Stained areas were found surrounding many of these sapwood wounds on aspen. Wagener and Davidson (1954) state that in many species sapwood exposed by wounding is rapidly transformed through traumatic response into pathological heartwood, which compares in all apparent respects with normal heartwood. Aspen appears to form pathological heartwood, but as no infections were found in the sapwood of balsam poplar surrounding wounds, it would appear that this species does not form this type of heartwood. Scars on balsam poplar were not found to be infected unless they were in contact with the heartwood. An exception occurs in the case of fire scars which were commonly infected by Armillaria mellea or slash destroying species of fungi.

An unusual type of defect was found to contribute heavily to the cull losses in the bottomland balsam poplar stands. This appeared as a long flattened to depressed area along one side of the tree with the bark retained intact. The defect and rot associated with it are shown in Plates 6 and 7. Fomes igniarius was found in association with this defect in every case. The defect occurred in each sample area but was confined to the balsam poplar growing on the bottomlands. Although it was not found on many trees in any area it was of major importance as it resulted in a rot column of from 30 to 60 feet long in the large trees on the river bottoms.

Frost cracks, burls, galls, and broken tops are relatively unimportant as entrance points for fungi. These may result in a considerable amount of waste during utilization as the fallers, believing that trees containing these defects are rotted, will leave them standing. Ring shake is often found associated with frost cracks, and any log containing shake is culled by the veneer log graders. Frost cracks on balsam poplar occur near the base of the tree, rarely extending more than 4 feet from the ground level. A narrow stained area borders the crack but does not often yield cultures of wood destroying fungi. Frost cracks on aspen extend much higher above the ground, but again decay is not often associated with them. These cracks close early in the spring and are bridged readily by callus tissue, thus affording protection against spores of heartrotting fungi.

A grayish-black to orange colored stain is usually found descending to a distance of to 6 feet below broken tops of poplar. This stain rarely yielded cultures of wood destroying species of fungi. Burls and galls may have a green to brown colored stain associated with them, but it is not due to the presence of heartrotting fungi.

CHAPTER VI

FUNGI ASSOCIATED WITH DECAY IN LIVING ASPEN AND BALSAM POPLAR

Tables XII, and XIII list the fungi encountered in this survey in probable order of relative importance, and whether they occurred typically in the butts or trunks of trees.

One of the main problems in a survey of this type comes in the determination of the relative importance of the fungi responsible for the decay. Older studies (Schmitz and Jackson 1927, Meinecke 1929) based the identification of the causual fungus on the sporophores present on the tree. This method is limited in that sporophores are not always present on the tree, and many of the heartrotting fungi found in living trees may not produce sporophores on the living trees. These older studies named Fomes igniarius as the cause of the trunk rot and Fomes applanatus (Pers.)Gill. as the cause of the butt rot. Since the development of cultural procedures for the identification of rots these fungi have been found to be of much less importance than was originally thought. In the more recent studies (Black 1951, Black and Bourchier 1952, Black and Kristapovich 1954, and Basham 1958) Fomes igniarius has been found to be the cause of less than half of the volume of trunk rot, and *F. applanatus* has not been found in living aspen. Identification of rots by cultural characteristics alone may also produce erroneous results. This has been proven recently in a study by Nordin (1954) on the decay of sugar maple. In this study, *Corticium vellereum* was named as the second most important decay causing fungi on sugar maple. Later, Nobles and Nordin (1955) found this fungus to be a secondary rot, attacking wood already destroyed in part by another fungus.

Problems of this sort have also arisen in this study. On the basis of cultural identification alone, *Libertella* spp., a member of the fungi imperfecti, would probably be classed as one of the most important rots in aspen and balsam poplar, because of its frequent isolation. Upon inspection of the samples it was evident that this fungus was associated with many types of rots, and probably not the primary cause of any of them. The decay-causing status of this fungus is far from being solved however. Fritz (1954) found *Libertella* to be capable of attacking sound poplar wood in the laboratory. Basham (1958) has reported this fungus to be associated with a red mottled stain of aspen in Ontario but has been unable to obtain definite indication of its ability to cause decay. Preliminary tests at the Calgary laboratory have shown that this fungus does not cause decay in sterilized sound poplar wood. On the basis of these results, Libertella is believed to be capable of attacking only that wood partially destroyed by another fungus.

It is the belief of the author that the importance of F. igniarius may be somewhat overemphasized in aspen. This fungus is attributed with approximately 40 per cent of the total volume of wood destroyed. It was found most prevalent in older aspen. Corticium polygonium is the fungus most prevalent in the younger age classes of aspen, and it is often found with F. igniarius in the older trees (Plate 8). It would appear that F. igniarius may attack wood that has been partly destroyed by C. polygonium. If this is the case, the volume of wood destroyed should be attributed to C. polygonium instead of being distributed among the two fungi.

Armillaria mellea was the most frequently isolated fungus from basal rots of aspen, and was the second most frequent from balsam poplar. In the incipient stage this rot shows up as a brownish stain in balsam poplar or as a yellowish stain in aspen. The advanced stage of rot caused by A. mellea is spongy, white, and contains numerous narrow, wine colored zone lines. Infection of the tree takes place through the roots from the rhizomorphs present in the soil. Wounds need not be present on the roots for infection to take place because the rhizomorphs are capable of penetrating the cork cells by mechanical action (Butler and Jones 1949). The honey colored sporophores of _A. mellea_ are found on old stumps and logs, in crevaces in the butt of the trees, or on the ground near the base of the tree. _Armillaria mellea_ would prove difficult to eradicate from the forest since it is capable of living as a saprophyte in the soil (Butler and Jones 1949). Although the spores of this fungus may not be capable of causing infection, they may germinate on the soil, producing rhizomorphs, and thus spreading the disease. Eradication of the sporophores will provide only partial control of this root rot.

Pholiota spectabilis also ranked high as a cause of butt rot in aspen and balsam poplar. The incipient stage of this fungus in aspen appears as a light brown stain, occurring in eccentric round pockets within the heartwood. The advanced stage is yellowish to light brown and stringy. Sporophores of this fungus are light brown mushrooms with white scales on the cap. They are produced in abundance on old stumps.

Pholiota adiposa produces a similar rot to _P. spectabilis_ but is confined to aspen. Sporophores of this fungus are also similar to those of the previous fungus except that they are usually produced in the hollows between the roots of living aspen.

Stereum purpureum was the only other butt rot of any importance isolated from these species. It was confined to balsam poplar. This fungus is of great economic importance in that it causes the silver leaf disease of fruit trees. Infection by *S. purpureum* takes place through wounds. Plum trees have been found to be in condition for maximum infection when their carbohydrate concentration is at its highest, which occurs early in the spring (Butler and Jones 1949). Sporophores of this fungus are leathery, light purple in color, and resupinate or effused-reflexed in form. They are found in abundance on the ends of logs, (Plate 9). This disease is of such importance in Great Britain that the Silver Leaf Order of 1923 compels fruit growers to destroy all material killed by *S. purpureum* before the 15th of July each year.

Coprinus micaceus and *Collybia velutipes* are of very minor importance as causes of butt rots in Alberta.

Fomes igniarius accounted for a major portion of the decay in aspen and balsam poplar, although it was of much greater importance in aspen. Undoubtedly losses due to this fungus constitute a major threat to the successful management of poplars in the region. The advanced stage in aspen occurs as a white flaky mass bordered by a single brown zone line. This may be surrounded by a light red incipient stage (Plate 10). The sporophores (Plate 11) are produced in abundance on aspen but have not been observed on balsam poplar. Riley (1952) found that girdling was a more effective means of disposing of sporophore bearing trees than was felling. Six years after girdling only 10 per cent of the sporophores remained alive, but some new growth raised the total to 13 per cent of the original number. Sporophores on the felled trees after six years were reduced to 70 per cent of the original but new growth raised the total to 236 per cent of the original number.

The occurrence of _F. igniarius_ on balsam poplar is much different from that on aspen. A few small infections were found associated with branch stubs or scars but the major form of occurrence was in association with a canker. This appeared as a large flattened to depressed area along one side of the tree with the bark remaining firmly intact. The advanced stage of rot is yellowish and surrounded by black zone lines. The canker and rot are shown in Plates 6 and 7. This canker is usually present in the central portion of the bole, but was found in one case within the live crown. A similar canker caused by _F_. _igniarius_ var. _laevigatus_ has been reported on yellow birch by Campbell and Davidson (1941).

Other trunk rots in balsam poplar appear as light brown and mottled in the incipient stage, progressing to a light brown stringy advanced stage (Plate 12). The fungi responsible for this type of rot are primarily _Pholiota destruens_ and _Corticium expellans_. Of lesser importance are _Corticium vellereum_ and _Corticium laeve_. A large number of Hyphomycetes have been found present in this complex. Some of these produce bright orange to red stains when exposed to the air, as can be seen in the dark areas surrounding the rot in Plate 12. _Pholiota destruens_ produces tan colored sporophores with white scales on the cap, on old stumps and slash. _Corticium expellans_ produces small, purplish colored, effused-reflexed sporophores on the dead limbs of balsam poplar (Plate 13).

Corticium polygonium is most prevalent in the younger age classes of aspen in Alberta, and Basham (1958) reports this to be the case in Ontario. The rot produced by this fungus is a reddish-brown central core surrounded by a band of olive-green. In the upper portions of the trunk the coloring fades to a white central core surrounded by a light green band (Plate 14). The advanced stage is light brown and slightly stringy.

Sporophores of *C. polygonium* are very small, pink, resupinate, and occur on the underside of the dead limbs close to the trunk of the tree. Plate 15 shows the sporophores of *C. polygonium* on aspen slash.

Radulum casearium is the cause of a red stain and yellowish stringy rot in the older aspen in Alberta (Plate 16). Sporophores (Plate 17) are found on the underside of aspen slash. They are large, yellowish-white, resupinate, and have coarse blunt teeth.

Corticium polygonium and *Radulum casearium* together are responsible for more than one third of the total volume of aspen destroyed. They have never been reported attacking balsam poplar. Black (1953) in studying *R. casearium* concludes that the pH of the sap of balsam poplar may be inhibitory to the growth of fungus.

The remaining trunk rotting fungi of aspen are of little importance, contributing less than 5 per cent to the total volume of wood destroyed. These fungi have all been reported previously in Canada attacking either live aspen (Basham 1958, Black and Bourchier 1952, Black and Kristapovich 1954), aspen pulpwood in storage (Fritz 1954), or black cottonwood in British Columbia (Thomas and Podmore 1953).

Although cankers, other than those caused by *Fomes igniarius* on balsam poplar, are of little importance in northern Alberta, some mention must be made of them. The canker caused by _Hypoxylon_ _pruinatum_ (Klotsche)Cke. was found only 4 times on aspen during the two summers of field work. Should this canker ever become prevalent in the stands, it will undoubtedly become of major importance as it is probably the most serious enemy of aspen over most of the eastern part of the range of this species. It is therefore imperative that trees containing this canker be removed from the stands as they are encountered.

A canker reported by Meinecke (1929) on aspen in Utah and referred to by Boyce (1948) as the black canker of aspen was found occurring on two trees, on one plot in the Goodwin area. It is not known whether this canker is of a parasitic nature.

CHAPTER VII

HEARTROTS IN RELATION TO THE MANAGEMENT OF POPLARS

This section is a review of various factors entering into the management of poplars and the disease implications of each factor.

Cutting Methods

Many studies have been made of the reproductive needs of aspen. The results of these studies are probably applicable in a general way to balsam poplar since the two species are closely related.

Aspen and balsam poplar, although prolific seeders, reproduce mainly by means of root suckers. Some suckers may arise in uncut stands but the most vigorous and abundant suckering is produced when strong light and heat reach the forest floor. Baker (1925) showed that 3 year old aspen sprouts averaged 8.7 inches in height under 25 per cent of full sunlight, while those under full light averaged 42.3 inches in height. Laboratory experiments by Sandberg and Schneider (1953) demonstrated that increased light intensities stimulated the development of new roots, and resulted in a more even rate of height growth, and better secondary growth of the suckers.

The number of suckers produced may be proportional to the degree of cutting and age of the parent stand. Kittredge and Gevorkiantz (1929) found that more suckers were produced from older parent trees if they were vigorous at the time of cutting. Zehngraff (1949) shows that the greatest number of suckers were produced following clearcutting and the least number were produced under the selection cut leaving the greatest basal area per acre.

The time of the year in which cutting is done may influence the numbers, vigor, and survival of the suckers. Aspen roots are believed to be depleted of their stored food in the summer and thus lack the ability to produce vigorous suckers. Suckers produced late in the season will be more easily winter killed than those produced in the spring. Zehngraff (1947) in reporting these results recommends that logging be carried out in the winter so that the suckers will have a better chance of survival, and will be able to compete more favorably with the brush species.

Other methods that have been used to increase suckering are light controlled burns (Shirley 1931), disking with an Athens type disk plow (Zehngraff 1949), and poisoning the parent trees with ammonium sulphamate (U.S.F.S. 1951).

One point often raised against sucker originated stands is that root rots may be spread through the parent root. Schmitz and Jackson (1927) in a study of the heartrots of aspen found no evidence proving that suckers had been infected from the parent root. Zehngraff (1947) found that about one half of the suckers sampled were stained to some degree, but he concluded that there were enough stain free suckers to assure a fully stocked stand. Suckers containing rot originating from the mother root will likely make up a large proportion of the natural mortality that occurs in the young poplar stands. Root rots, by destroying the water conducting tissue of the smaller roots, will result in weaker trees, more susceptable to death through supression than neighbouring trees which are free from root rots.

In order to obtain the most abundant and vigorous reproduction, existing stands should be harvested by a clearcutting method. Clearcutting also provides maximum silvicultural control over wood destroying fungi. Clearcutting assures that all defective trees will be removed in the logging operation. Many highly defective trees show no outward signs of decay and could be missed during marking operations for a selective cut. Clearcutting avoids injury to residual trees which might serve as entrance points for heart-rotting fungi. These logging injuries have been proven to be important as entrance points on a number of species in studies by Englerth and Isaac (1944), Engle (1947), and Hesterberg (1957). Clearcutting provides a feasible means of harvesting stands before the age at which decay has caused considerable losses is reached.

Sporophore-bearing trees, if not removed from the woods, should be burned with the logging slash. Many important heartrots are capable of fruiting on fallen trees. *Radulum casearium*, *C. polygonium*, *A. mellea*, *Pholiota* spp., *S. purpureum*, and some of the less important species such as *P. adustus*, *P. zonatus*, and *C. velutipes* have been observed during the course of the study, fruiting on slash. *Fomes igniarius* was not observed fruiting on slash in Alberta but Riley (1952) reports sporophores of this fungus being produced on slash in Ontario. Hepting and Roth (1950) report that sporophores of the genus Fomes may continue to produce spores for 15 years after the tree has been felled. They state that the felling of conky trees can be depended upon to reduce the distribution of spores since the conks will lie closer to the ground where they are out of the wind currents.

Thinnings

Following fires or clearcutting, poplar sprouts become established in large numbers. Stagnation due to overstocking is extremely rare however, as the species are characterized by a pronounced ability to express dominance, (Kittredge and Gevorkiantz 1929).

Aspen has been shown to respond exceptionally well to thinnings in the Lake States. Zehngraff (1947) found that an 8 X 9 foot spacing produced the best results in diameter and volume growth. Pike (1947) in Manitoba believes that thinning may stimulate volume and diameter growth but that the same results are secured by natural thinning. His conclusion was based on basal area per acre after 10 years with no regard to merchantable volume.

The advantages of thinning from a pathological standpoint are few, and may easily be offset by the disadvantages of this practice. Heavy thinning may reduce the rotation age by concentrating the volume on a smaller number of trees thus taking advantage of lower cull per cents in the younger trees. Thinnings should play the part of a sanitation cut, removing the more defective trees, and reducing the source of infection in the forest. However, scars produced on the trunk and roots of the residual trees during the thinning operation may serve as entrance points for fungi. Bickerstaff (1946) reported a large amount of sunscald to residual aspen after a thinning operation. Riley (1948) found the incidence of Hypoxylon canker to be higher on thinned plots than on the unthinned plots in Ontario, but Zehngraff (1949) found the opposite to be true in Minnesota. This canker is not prevalent in northern Alberta but is found extensively throughout the main parkland region of the province.

Balsam poplar produces epicormic branches when the bole is exposed to sunlight. These result in degrade in the finished veneer. Fungi such as A. mellea and Pholiota spp. fruit prolifically on the stumps of cut poplar. This may provide a greater source of infection to the remaining trees, although there is some doubt as to whether A. mellea is capable of causing infection by spores.

If thinnings are to be carried out in poplar stands they should be done carefully to avoid damage to the residuals. Thinnings should not be heavy enough to expose the bole to light from the side as this may hinder natural pruning, promote the development of epicormic branches, or cause winter sunscald injury to the residuals. Thinnings should include the removal of overtopped trees, and any trees with scars, sporophores, or excessive numbers of dead limbs. All material removed in the process of thinning should be burned if it is not to be utilized, as it may serve as a breeding ground for fungi if left in the forest.

Pruning

Virtually all of the high grade plywood logs in Alberta come from the rapidly dwindling old growth balsam poplar stands on the bottomland surrounding rivers. These stands are likely to be the first brought under management by the plywood industries. Rotations long enough to produce the size of logs now being harvested will be uneconomical in managed forests. Plywood logs will eventually come from relatively small trees and pruning will probably become an important practice on better sites in the production of veneer logs. If this practice evolves, the amount of decay may be materially reduced, as dead branch stubs are the most important entrance points for the decay causing fungi.

To be successful as a preventative measure against decays, pruning must be done while the trees are still young. At 20 years of age very few poplar have been infected by heartrots. Trees of this age are tall enough that they may be pruned to a height of 16 feet without affecting their growth rates, as pruning to this height will remove but few live branches.

Dead branches are retained for 5 to 10 years on trees in dense stands and for much longer periods in open grown stands. Artificial pruning would greatly reduce the chance of infection of the branch stubs by shortening the period of time between the death of the branch and the healing over of the scar.

Rotation

One of the most prominent factors affecting decay losses is the age at which the stand is cut. These losses can be held to a minimum by selecting a very short rotation, but under present market conditions we must accept the higher losses of the older stands.

Pathological rotations are based on the culmination of net periodic increment. Meinecke (1929) recommends a pathological rotation age of 80 to 90 years for aspen in Utah, and in Minnesota, Schmitz and Jackson (1927) recommend a 40 to 50 year rotation for this species. Net increment of aspen did not reach its highest point in the age classes sampled in Alberta and it is assumed that it will culminate at a much older age than was found in the sample. The net increment in balsam poplar culminates at 140 years in this sample. At the present value of poplar a rotation age of this length cannot justify itself, but yet the value increase in poplar from the age of 90 years onwards probably offsets the value decrease due to decay. Poplar in Alberta now presents a case much different than would be encountered if markets existed for all sizes of material. The value of poplar may be considered as nil until the stand has reached the age at which it will produce veneer logs. From this age on, value increases rapidly. In order to reduce the rotation age of poplar, higher quality trees will have to be grown in shorter periods of time, and this will probably require the undertaking of artificial pruning.

Boyce (1948) sums up rotations by saying that there can be only one, and that this will be determined by the interaction of financial, technical, silvicultural, and pathological considerations.

Sites

The effect of site quality on the amount of decay present in a stand is not well understood. Zehngraff (1947) shows cull per cents of aspen increasing as tree vigor and site quality decrease. It appears that cull per cents on the poor sites were based on estimates and not actual measurements in this study. The author states that there were no scale records from poor sites as there had been no timber sales on these sites. Riley (1952) found that cull per cents in aspen in Ontario, based on board feet measurements, were lower on the better sites. No such relationship existed for the cubic foot percentages. Schmitz and Jackson (1927) conclude that the rate of growth did not affect the percentage of decay in aspen in Minnesota. Black (1951) found that cull per cents based on board feet measurements were consistently greater in aspen on poor sites in northern Ontario.

Cull per cents based on scaling procedures and board feet volumes should not be considered adequate proof that a difference in decay between sites exists. With a given percentage of decay, a higher cull per cent will result in the smaller trees on poor sites than in the larger trees on better sites when scaling is done in board feet. This is due to the standard trim allowance added to the rot diameter regardless of the size of the log, and to the culling of complete logs when decay exceeds a given per cent.

Basham (1958) found aspen to have a higher incidence of butt rot on dry sites than on other sites. This is possibly a result of the air-water relations in the heartwood of poplar. The heartwood of these species normally contains a high percentage of water, and on moist sites the water content may be high enough to inhibit the growth of fungi.

Site quality may influence the establishment of decays in the tree. Natural pruning is better on good sites because of the greater crown closure. Scars and branch stubs on vigorous trees will heal over faster, thus affording less chance of infection by heartrotting fungi. Shorter rotations on the good sites will take advantage of the lower decay per cents in the younger trees.

Considering the large volume of unmerchantable aspen present in the province, and the probable over-supply for some years to come, the conversion of the poorer aspen sites to more valuable species should be considered. White spruce reproduction is often present in the pure aspen stands, and it is this type which produces the high quality spruce of the mixed-wood type at later ages.

The exclusion of fires from the stands is essential in converting aspen to the mixed-wood type. Repeated fires increase the density of the aspen cover by replacing the older stands with dense young stands of suckers.

Light controlled burns may be benificial to the introduction of conifers. A duff layer, one to two inches thick, composed of leaves pressed flat into a dense mat covers the mineral soil of most stands. This layer may prevent seeds from reaching the mineral soil and absorbs much of the moisture from light rains. A controlled burn would have to be light enough to remove this duff layer without stimulating suckering.

Young aspen stands are very dense, and spruce reproduction in them is suppressed due to shade or root competition. The lack of any shade may result in the death of the spruce seedlings due to excessive heat or frost heaving. Release cuttings would be benificial if they were not heavy enough to produce a crop of vigorous suckers, but would be a detriment if they allowed vigorous sucker growth.

SUMMARY

During the summers of 1957 and 1958, 43 sample plots containing 1136 trees were analized. These were located in poplar types in west-central Alberta.

The incidence of decay averaged 89.6 per cent for aspen, and 93.2 per cent for balsam poplar.

The percentage of decay in aspen rose from nil at 20 years to 33.2 at 100 years of age. The percentage of decay in balsam poplar rose from nil at 20 years to 17.2 at 150 years of age.

The amount of decay did not appear to be influenced by site quality when sites were classified on an ecological basis. However, fast-growing trees contained a lower percentage of decay than slow-growing trees.

Cull figures that can be applied to the estimation of volumes from aerial photographs are presented.

Branch stubs were found to be the most important infection courts for the decay-producing fungi. Scars caused by fire resulted in more decay than similar sized scars caused by other agencies.

Fomes igniarius was found to be the most important heartrotting fungus on aspen and balsam poplar. Fourteen other fungi were isolated from aspen and 8 others from balsam poplar.

Factors entering into the management of poplars and the disease implications of these factors are discussed.

APPENDIX

Smalians formula for deriving the cubic content of logs:

$$V = \frac{B + b}{2} \cdot L$$

where B is basal area in sq. ft. of the large end of the log.

b is basal area in sq. ft. of the small end of the log.

L is length of the log in feet.

Maturity classes for poplars as used in the Alberta forest inventory are:

Reproduction	0-33 years
Young	34-66 "
Immature	67-99 "
Mature	100-133 "
Overmature	134 and more years.

Height classes used in the forest inventory are:

1	0-30 feet
2	31-60 "
3	61-80 "
4	81-100 "
5	101 and more feet.

Three site-index classes are recognized in poplar stands for inventory purposes. The index age is 80 years.

Total Height Of Average Dominant Poplar In Feet

Site-Index Class

Age	Good	Medium	Poor
10	more than 20	13-20	less than 13
20	33	25-33	25
30	45	35-45	35
40	54	42-54	42
50	60	48-60	48
60	66	53-66	53
70	70	57-70	57
80	75	60-75	60
90	78	63-78	63
100	82	65-82	65
110	84	68-84	68
120	86	69-86	69
130	87	71-87	71
140	88	72-88	72
150	89	73-89	73

TABLE II

BASIC DATA ON ASPEN

Location	No. of trees	Ave. age	Ave. d.b.h.	Gross Volume Cu. Ft.	Gross Volume Bd. Ft.	Decay Volume Cu. Ft.	Decay Volume Bd. Ft.	Per cent Decay Cu. Ft.	Per cent Decay Bd. Ft.
				Aspen in pure stands					
Faust	129	82	9.6	2573.2	9792	895.2	8242	34.8	84.2
Whitecourt	116	68	8.1	1208.6	3677	312.1	2968	25.8	80.7
Simonette	87	61	6.0	441.9	874	82.0	690	18.6	78.9
Goodwin	46	31	5.4	132.8	134	11.8	58	8.9	43.3
Total	378			4356.5	14477	1301.1	11958		
Average				11.5	38			29.9	82.6
				Aspen in mixed stands					
Faust	166	65	9.1	3030.8	11831	903.0	9856	29.8	83.3
Whitecourt	41	47	7.8	411.3	1092	42.8	522	10.4	47.8
Simonette	19	62	8.8	278.0	931	52.8	625	19.0	67.1
Total	226			3720.1	13854	998.6	11003		
Average				14.0	52			26.8	79.4
Average all aspen								28.5	81.0

TABLE III

BASIC DATA ON BALSAM POPLAR

Location	No. of trees	Ave. age	Ave. d.b.h.	Gross Volume Cu. Ft.	Gross Volume Bd. Ft.	Decay Volume Cu. Ft.	Decay Volume Bd. Ft.	Per cent Decay Cu. Ft.	Per cent Decay Bd. Ft.
Bottomland balsam poplar stands									
Simonette	77	90	16.0	3653.4	17602	349.6	4406	9.6	25.0
Goodwin	159	53	10.0	2779.3	11996	125.7	1985	4.5	16.5
Swan River	28	128	23.8	3413.2	18882	711.7	8960	20.9	47.5
Total	264			9845.9	48480	1187.0	15351		
Average				37.3	184			12.1	31.7
Balsam poplar in mixed stands									
Faust	138	69	11.2	3351.8	14006	351.4	4732	10.5	33.8
Simonette	17	62	9.3	225.5	680	5.3	81	2.4	11.9
Whitecourt	113	53	8.6	1265.9	3869	16.6	1068	1.3	27.6
Total	268			4843.2	18555	373.3	5881		
Average				18.1	69			7.7	31.7
Average all balsam poplar								10.6	31.7

TABLE IV

RELATION BETWEEN AGE AND INCIDENCE OF DECAY

IN ASPEN AND BALSAM POPLAR

Age Class	Per Cent of Trees Containing Decay	
	Aspen	Balsam poplar
21-40	62	74
41-60	95	100
61-80	100	100
81-100	100	100
101-120	100	100
121-140		100
141-160		100
Average all trees	89.6	93.2

TABLE V

RELATION BETWEEN AGE, GROSS VOLUME, DECAY VOLUME,

AND INCREMENTS IN ASPEN

Basis 604 Trees
(Curved Values)

Age	Average Gross Volume (Cu.Ft.)	Average Decay Volume (Cu.Ft.)	Average Net Volume (Cu.Ft.)	Per Cent of Decay	Gross Increments (Cu.Ft.)		Net Increments (Cu.Ft.)	
					Periodic	Mean Annual	Periodic	Mean Annual
20	1.0	0.0	1.0	0.0		0.05		0.05
30	2.1	0.2	1.9	9.6	1.1	0.07	0.9	0.06
40	3.5	0.5	3.0	14.3	1.4	0.09	1.1	0.07
50	5.7	1.0	4.7	17.6	2.2	0.11	1.7	0.09
60	8.7	1.8	6.9	20.7	3.0	0.15	2.2	0.11
70	13.0	3.3	9.7	25.4	4.3	0.19	2.8	0.14
80	17.9	5.1	12.8	28.5	4.9	0.22	3.1	0.16
90	24.1	7.8	16.3	32.3	6.2	0.27	3.5	0.18
100	31.0	10.3	20.7	33.2	6.9	0.31	4.4	0.21
110	38.3	11.9	26.4	31.2	7.3	0.35	5.7	0.24

TABLE VI

RELATION BETWEEN AGE, GROSS VOLUME, DECAY VOLUME,

AND INCREMENTS IN BALSAM POPLAR

Basis 532 Trees
(Curved Values)

Age	Average Gross Volume (Cu.Ft.)	Average Decay Volume (Cu.Ft.)	Average Net Volume (Cu.Ft.)	Per Cent of Decay	Gross Increments (Cu.Ft.)		Net Increments (Cu.Ft.)	
					Periodic	Mean Annual	Periodic	Mean Annual
20	2.0	0.0	2.0	0.0		0.10		0.10
30	2.8	0.1	2.7	3.6	0.8	0.09	0.7	0.09
40	5.0	0.2	4.8	4.0	2.2	0.12	2.1	o.12
50	9.2	0.4	8.8	4.3	4.2	0.18	4.0	0.16
60	15.3	0.7	14.6	4.6	6.1	0.25	5.8	0.24
70	23.0	1.2	21.8	5.1	7.7	0.33	7.2	0.31
80	32.9	2.2	30.7	6.7	9.9	0.41	8.9	0.38
90	44.3	4.1	40.2	9.3	11.4	0.49	9.5	0.45
100	58.0	6.6	51.4	11.4	13.7	0.58	11.2	0.51
110	72.7	10.2	62.5	14.1	14.7	0.66	11.1	0.57
120	88.3	13.8	74.5	15.6	15.6	0.74	12.0	0.62
130	105.0	17.6	87.4	16.8	16.7	0.81	12.9	0.67
140	122.2	21.0	101.2	17.2	17.2	0.87	13.8	0.72
150	139.3	23.9	115.4	17.2	17.1	0.93	13.2	0.77

TABLE VII

COMPARISON OF GROSS AND DECAY VOLUMES

IN FAST AND SLOW GROWING ASPEN

(Curved Values)
Basis
268 slow growing trees
336 fast growing trees

Age	Average Gross Volume		Average Decay Volume		Percentage of Decay	
	Fast	Slow	Fast	Slow	Fast	Slow
20	2.1	0.5	0.0	0.0	0.0	0.0
30	4.2	0.9	0.3	0.1	7.2	11.1
40	7.1	1.6	1.0	0.3	14.1	18.7
50	10.7	2.8	1.9	0.7	17.8	25.0
60	15.4	4.5	3.4	1.3	22.1	28.9
70	21.1	6.9	5.3	2.3	25.2	33.4
80	28.3	10.0	7.7	3.6	27.2	36.0
90	37.7	14.6	10.7	5.3	28.4	36.3
100	49.8	21.2	15.5	7.9	31.2	37.3
110		33.6		12.2		36.4
Average					26.0	34.9

Note: Fast means fast growing
Slow means slow growing
Volumes in cubic feet.

TABLE VIII

COMPARISON OF GROSS AND DECAY VOLUMES

IN FAST AND SLOW GROWING BALSAM POPLAR

(Curved Values)
Basis
300 slow growing trees
232 fast growing trees

Age	Average Gross Volume		Average Decay Volume		Percentage of Decay	
	Fast	Slow	Fast	Slow	Fast	Slow
30	4.7	0.9	0.0	0.1	0.0	11.1
40	9.8	2.2	0.0	0.3	0.0	13.6
50	16.4	5.1	0.6	0.6	3.7	11.8
60	25.4	8.3	1.1	0.9	4.3	10.8
70	38.0	13.3	1.4	1.6	3.7	12.0
80	53.3	19.3	2.5	2.5	4.7	12.9
90	70.6	27.0	5.2	3.7	7.4	13.7
100	87.9	36.2	8.1	5.1	9.2	14.1
110	104.1	47.7	11.2	6.7	10.7	14.1
120	119.6	60.7	16.5	9.0	13.8	14.8
130		75.6		12.6		16.8
140		91.3		17.5		19.2
150		107.1		22.5		21.0
Average					8.8	16.8

Note: Fast means fast growing
Slow means slow growing
Volumes in cubic feet.

TABLE IX

CULL PER CENTS BY HEIGHT CLASSES FOR USE IN THE GENERAL FOREST INVENTORY

Height Class	% Cull Bd.Ft.	Basis No. of trees	% Decay Cu. Ft.	Basis No. of trees
2	28.8	5	7.6	223
3	59.1	41	21.8	321
4	40.2	262	17.9	501
5	39.5	61	16.1	64

TABLE X

CULL PER CENTS BY MATURITY CLASSES AND SITES FOR USE IN THE DETAILED FOREST INVENTORY

Maturity Class	% Cull Bd.Ft.	Basis No. of trees (curved)	% Decay Cu. Ft.	Basis No. of trees (curved)
		Good Sites		
Reprod.	---		---	
Young	17.2		18.5	
Immature	34.1	345	16.2	913
Mature	39.9		16.3	
Overmat.	49.9		30.6	
		Medium Sites		
Reprod.	---		---	
Young	69.0		13.6	
Immature	94.4	27	43.5	212
Mature	100.0		49.8	

See page 52 for definitions of height maturity and site.

TABLE XI

CULL PER CENTS BY HEIGHT CLASSES AND SITES

FOR USE IN THE DETAILED FOREST INVENTORY

Height Class	% Cull Bd.Ft.	Basis No. of trees	% Decay Cu. Ft.	Basis No. of trees
		Good Sites		
2	28.8	5	7.6	223
3	39.4	24	9.2	133
4	38.7	253	17.2	480
5	39.5	61	16.1	64
		Medium Sites		
2	---		---	
3	76.7	17	32.8	188
4	95.7	9	44.8	21
5	---		---	

See page 52 for definitions of height class and site.

TABLE XII

FUNGI ISOLATED FROM LIVING ASPEN*

BUTT ROTS

Armillaria mellea (Vahl. ex Fr.) Quel.
Pholiota adiposa Fr.
Pholiota spectabilis (Fr.) Quel.
Coprinus micaceus Fr.
Collybia velutipes Fr.

TRUNK ROTS

Fomes igniarius Gill.
Corticium polygonium Pers.
Radulum casearium (Morgan) Lloyd
Phlebia strigosozonata (Schw.) Lloyd
Polyporus zonatus Fr.
Polyporus adustus Fr.
Trechispora raduloides (Karst) Rog.
Merulius tremellosus Shrad. ex Fr.
Trametes trogii Berk.
Fomes fomentarius (Fr.) Kickx.

* Listed in probable order of relative importance.

TABLE XIII

FUNGI ISOLATED FROM LIVING BALSAM POPLAR *

BUTT ROTS

Pholiota spectabilis (Fr.) Quel.
Armillaria mellea (Vahl. ex Fr.) Quel.
Stereum purpureum (Pers.) Fr.

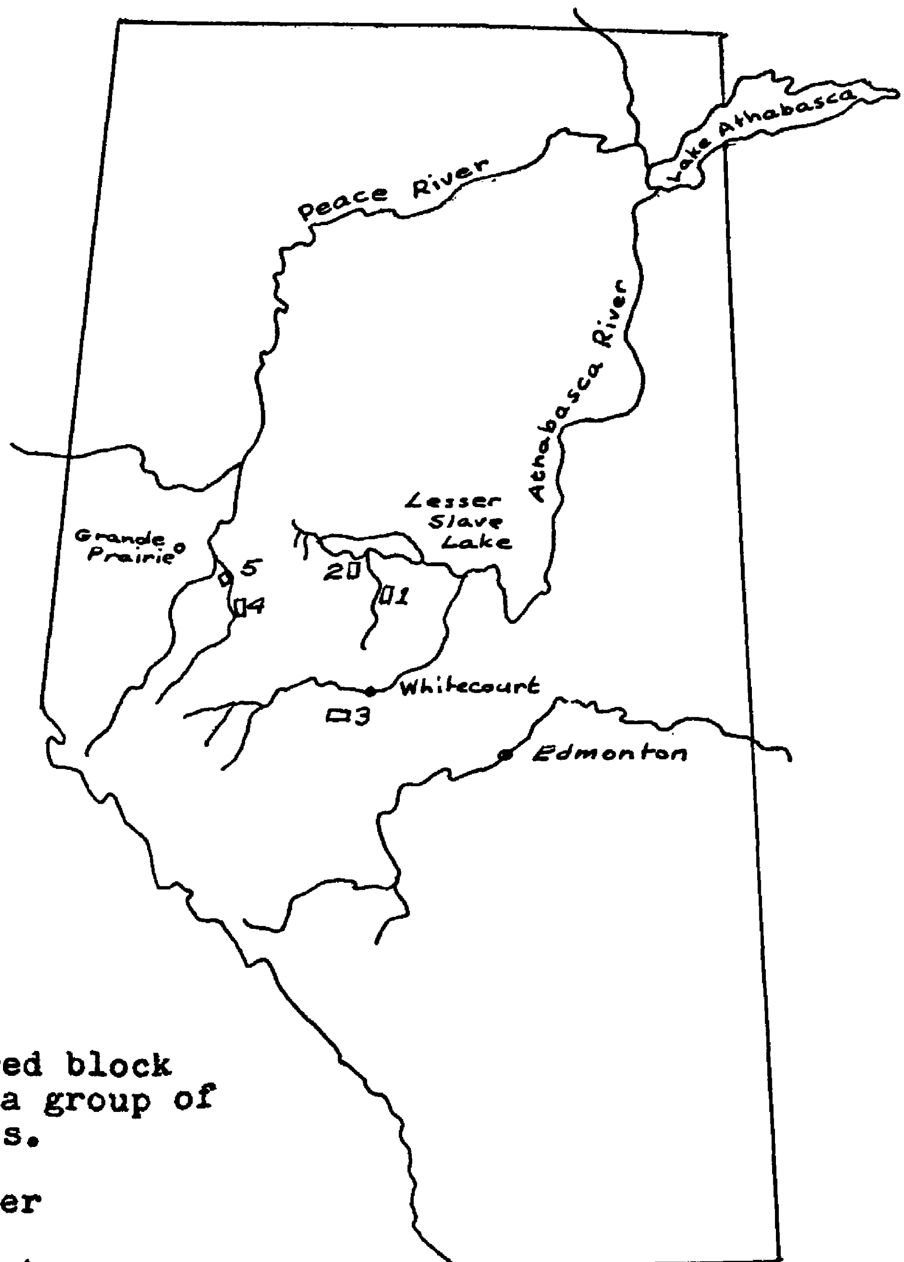
TRUNK ROTS

Fomes igniarius Gill.
Pholiota destruens (Brond.) Quel.
Corticium expellans Bres.
Corticium vellereum Ellis and Cragin
Corticium laeve Pers.
Polyporus adustus Fr.

* Listed in probable order of relative importance.

PLATE 1

LOCATION OF SAMPLE AREAS



Each numbered block represents a group of sample plots.

1. Swan River
2. Faust
3. Whitecourt
4. Simonette River
5. Goodwin

PLATE 2

A 55 year old stand of aspen and balsam poplar in the Whitecourt area.

PLATE 3

A 100 year old stand of balsam poplar on the bottomland surrounding the Simonette River

PLATE 4

An interior view of the stand in Plate 3.

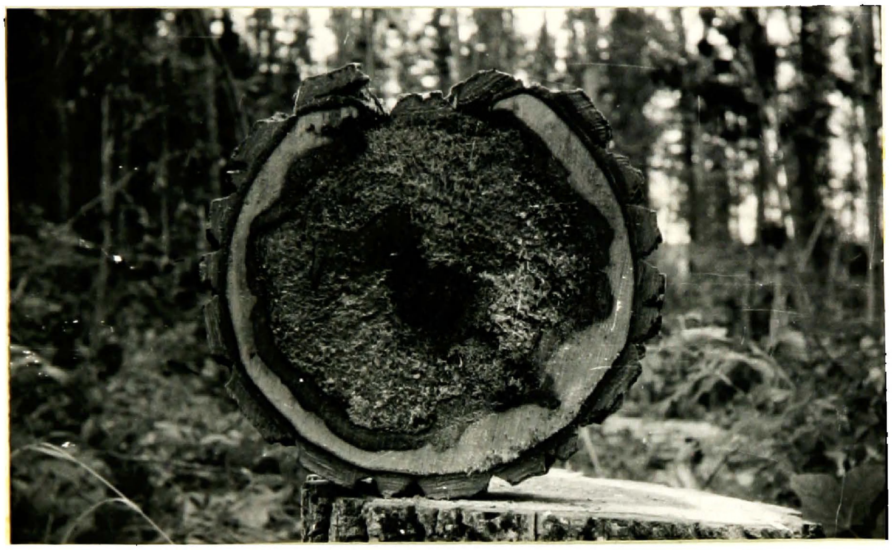
PLATE 5

A fire scar on the butt of an aspen tree.

PLATE 6

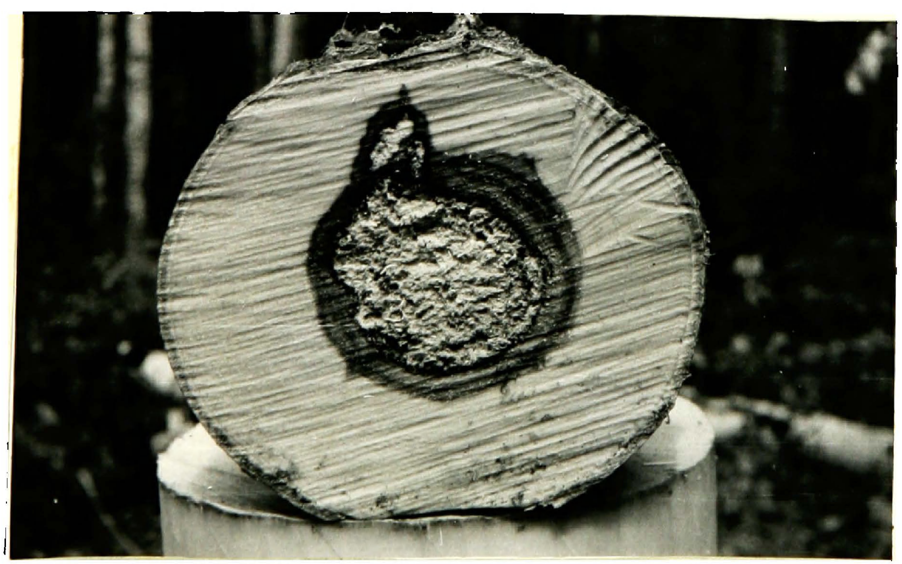
A large canker on balsam poplar, possibly caused by the fungus _Fomes igniarius_.

PLATE 7



Fomes igniarius in association with the canker in Plate 6.

PLATE 8



The advanced stage of Fomes igniarius in aspen surrounded by an olive-green band caused by Corticium polygonium.

PLATE 9

Sporophores of Stereum purpureum on the end of an old balsam poplar log.

PLATE 10

The advanced stage of Fomes igniarius in aspen.

PLATE 11

Sporophores of Fomes igniarius
on aspen

PLATE 12

Light brown stringy rot typical of trunk rots in balsam poplar.

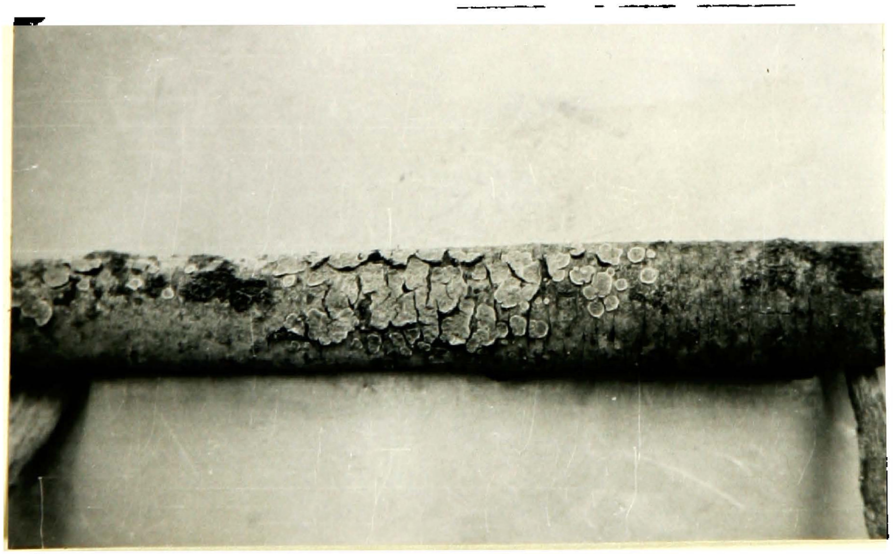
PLATE 13

Sporophores of Corticium expellans on a dead balsam poplar limb.

PLATE 14

Rot caused by Corticium polygonium in aspen. The numbers represent the height of the cut.

PLATE 15



Sporophores of Corticium polygonium on a dead aspen limb.

PLATE 16

Trunk rot in aspen caused by Radulum casearium.

PLATE 17

Sporophore of Radulum casearium on a dead aspen log.

PLATE 18

Sporophores of Polyporus zonatus on a dead aspen log.

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